Solar Power Technology for Electricity Generation

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***Abstract*- In this paper solar energy technologies are reviewed to find out the best option for electricity generation. Using solar energy to generate electricity can be done either directly and indirectly. In the direct method, PV modules are utilized to convert solar irradiation into electricity. In the indirect method, thermal energy is harnessed employing concentrated solar power (CSP) plants such as Linear Fresnel collectors and parabolic trough collectors. In this paper, solar thermal technologies including soar trough collectors, linear Fresnel collectors, central tower systems, and solar parabolic dishes are comprehensively reviewed and barriers and opportunities are discussed.**

INTRODUCTION

Due to the increase in world population, development in industrial activities, and enhancement in living standards, the Human demand for electricity will grow in the future years. Thus, it is necessary to explore appropriate alternatives sources for electricity generation which are environmentally benign and sustainable. Solar energy is one of the most attractive sources of energy for electricity generation. Typically, solar energy harnessed in the daytime needs to be stored (thermally or electrically) for utilization in the night.

SOLAR THERMAL POWER GENERATION SYSTEMS WITH VARIOUS SOLAR CONCENTRATORS

Concentrated solar power

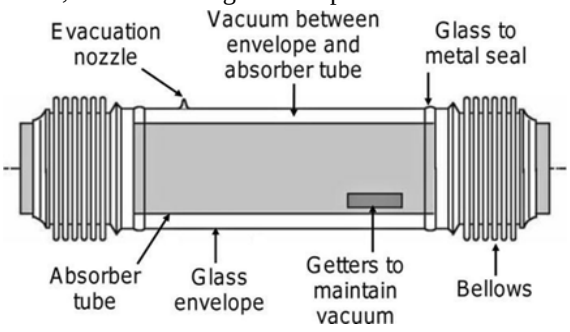
Concentrated solar power (CSP) utilize lenses and mirrors in order to focus solar irradiation on a small area. The concentrated radiation can be applied to generate electricity indirectly. The absorbed heat from solar irradiation is used in thermodynamic cycles in order to produce electricity.12 these systems are able to generate electricity even in the absence of sun which can be enumerated as their main advantage compared to solar power technologies. The most important issues pertaining to solar power plants using CSP technology are13:

- High efficiency is obtainable since the thermodynamic cycles are fed by high-temperature input.
- CSP technology uses only the direct component of incoming solar radiation, but it implies the loss of the diffused and reflected components.
- CSP systems' performance will boost up in locations with higher amounts of Direct Normal Irradiation (DNI).
- CSP systems are not appropriate for small-scale power generation since they require high capital cost.

SOLAR THERMAL POWER GENERATION SYSTEMS WITH PARABOLIC TROUGH CONCENTRATORS

A parabolic trough concentrator (PTC) utilizes the line focus technology for the CSP. This technology attracts intentions in 1980s due to oil crises.15 PTC consists of collector with long parabolic trough and a pedestal as support of the collector. This technology focuses solar irradiations on its focal line. A receiver is located there which absorb the heat. High absorptance material is utilized to coat the receiver. It is surrounded by a tube which is made of glass. In order to decrease heat losses, vacuum status is created between the tube and receiver as shown in Vacuum plays key role in receiver insulation and loss of vacuum can cause four times higher heat loss.16 Using lesser components and leakage-free glass

cover, vacuum leakage can be prevented.17



LINEAR FRESNEL REFLECTOR (LFR)

Arrangements of the reflective glass strips at the bottom of the system which rotates around in dependent parallel axis can be enumerated as characteristic of Linear Fresnel reflector (Figure 4). These strips focus on an elevated linear receiver, which further transfers the heat to the HTF. At the first step, it was introduced as a substitution for central receiver tower; however, it was as efficient as expected because of heat losses which were due to one axis tracking mechanism.58 Due to its some advantages like low capital cost and no revolute joints, and close exergy efficiency to parabolic trough collector for direct steam generation (DSG), it can be used instead of the parabolic collector

CENTRAL RECEIVER TOWER

Central receiver tower technology can be illustrated as a point focus kind of solar thermal electricity generation system. It has several heliostats which consist of dual axis control and an arrangement in order to focus radiation on stationary receiver (Figure 5). The stationary receiver is utilized in order to absorb the radiation which are concentrated by the heliostats. In addition, receivers are used to transfer heat to the heat transfer fluid (HTF), Afterward, HTF transfers the heat to the fluid used in power cycle.

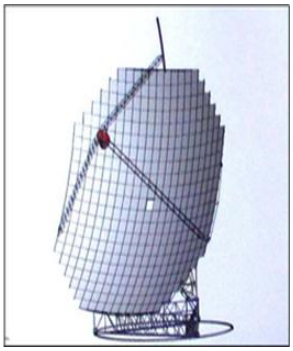
The ratio of the area of receiver to the total area of concentrating heliostats is equal to Concentration ratio (CR), as shown in Equation 15

$$CR = \frac{\text{Area of Receiver } (m^2)}{\text{Total Area of Heliostats } (m^2)} \quad (14)$$

The factors, which mainly influence on the reliability of these systems are temperature, the molten salt, corrosion, and the variation in solar flux. Changes in the mentioned factors lead to thermal stresses in the receiver. It is necessary to keep thermal stresses lower than d 50% of the ultimate tensile strength (UTS).

PARABOLIC DISH

Parabolic dish concentrators can be named as point focus type devices, which have two main parts: a solar thermal receiver located at the focal point and parabolic reflector (dish) (Figure 6). The characteristic of parabolic dish can be mentioned as having high temperature application, which is possibly appropriate for solar thermal power and solar thermal steam generation. The range of temperature for PDC fluctuates from 400°C to to750°C with concentration ratio more than 3000 and thermal efficiency 23%.



4.2.1 Environmental effects

In order to investigate the long-term sustainability of power generation systems, environmental effects must be considered. The main environmental issues which are related to solar power plants are in assembling and decommissioning. Almost no harmful effect exists after solar power plant commissioning and also during their operation.

In the process of PV cell manufacturing, various hazardous materials are utilized for semi-conductor surface cleaning; therefore, the risk of inhaling silicon dusts exist for workers involved in manufacturing.

CONCLUSION

Several studies related to solar energy are reviewed and their results are represented. First, various solar thermal power plants are compared. It is concluded that parabolic trough concentrator are more efficient in comparison with linear Fresnel reflectors; however, they require more investment cost. Other methods are introduced in order to obtain higher energy from the sun such as applying parabolic dish concentrator which are point focused devices and utilized for high temperature application. In addition to solar thermal power plants, solar energy can be directly converted to electricity by utilizing PV modules. PV systems are more applicable for small-scale power generation and have higher output electricity compared with CSP plants in the same area of installation. However, CSP plants have some advantages such as better economic return and lower CO2 emission.

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